NASA General Aviation Research
National General Aviation Roadmap
Smart Air Transport System

Presented to
Virginian Pilot

NASA Langley Research Center
December 20, 1999

Bruce J. Holmes
NASA General Aviation Program Office

Outline

The "Golden Rule" of the information age is "Time is the Scarce Commodity."

Early in the 21st century, the demand for personal transportation will soar beyond supply.

The Millennial Opportunity: SATS creates more time for more people.

- **Smart Air Transport System (SATS) Concept**
- **National Market Opportunities and Challenges**
- **Government-Industry Strategies**

Solving 21st Century Transportation Challenges

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The Smart Air Transport System is a safe travel alternative, freeing people and products from transportation delays, by creating access to more communities in less time.

Demand Will Soon Exceed Supply

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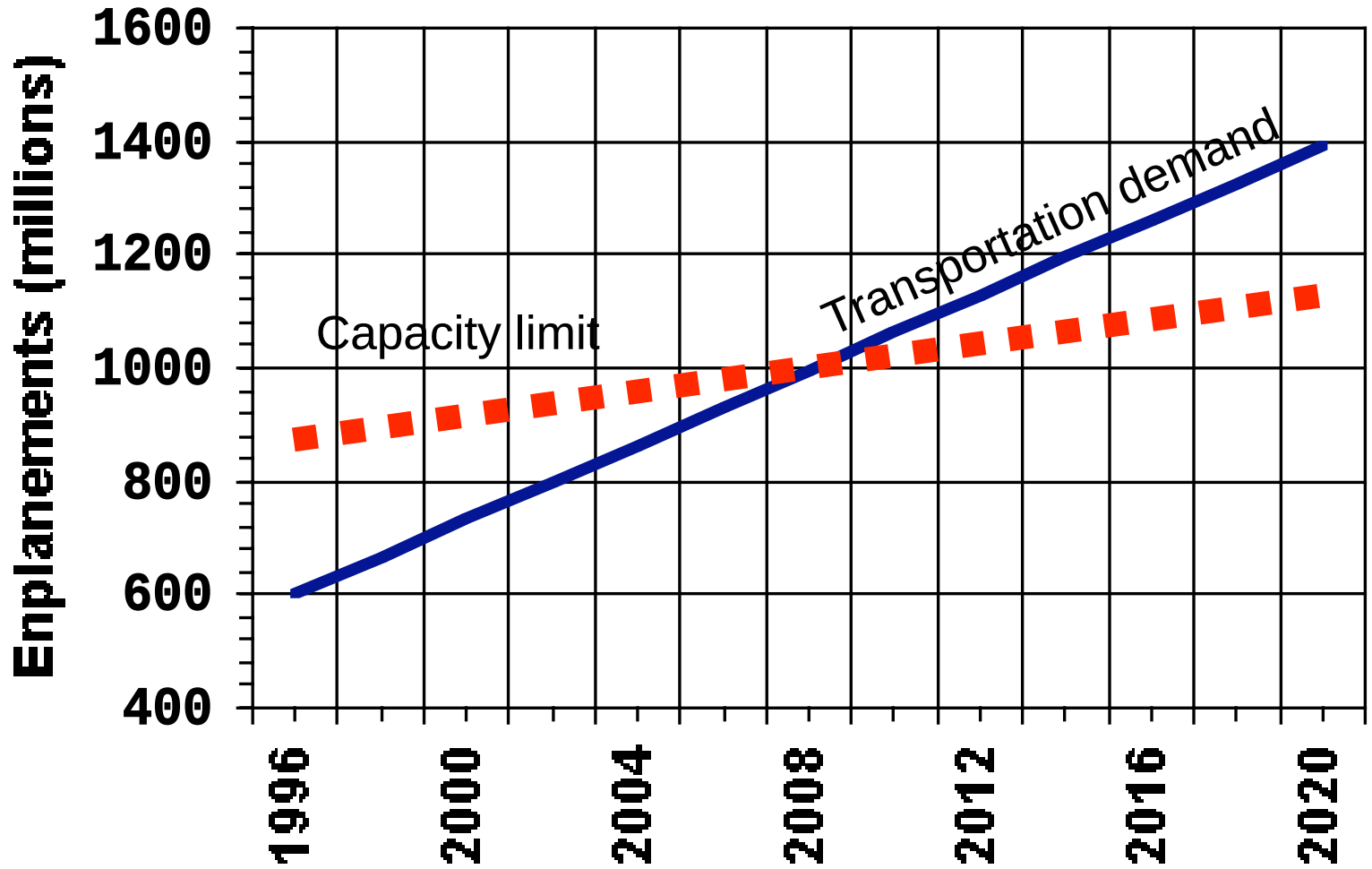

Strategic Planning Tenets

- **The innate human desire for personal command of time and space creates demand for distributed (personal) transportation systems.**
- **The Information Age will usher in a new magnitude for the value of time.**
- **The Baby Boom generation's peak spending (traveling) period coincides with saturation of the hub-spoke airway and interstate highway systems.**
- **The Third Migration Wave (beyond the suburbs), coupled with tele-commuting, creates new transportation demand and challenges.**
- **The revolution in digital bandwidth redistributes intelligence from centralized to distributed system nodes, enabling the aviation transition from centralized to distributed air traffic management (free flight).**

National General Aviation Roadmap Goal

(Revision Draft in Review)

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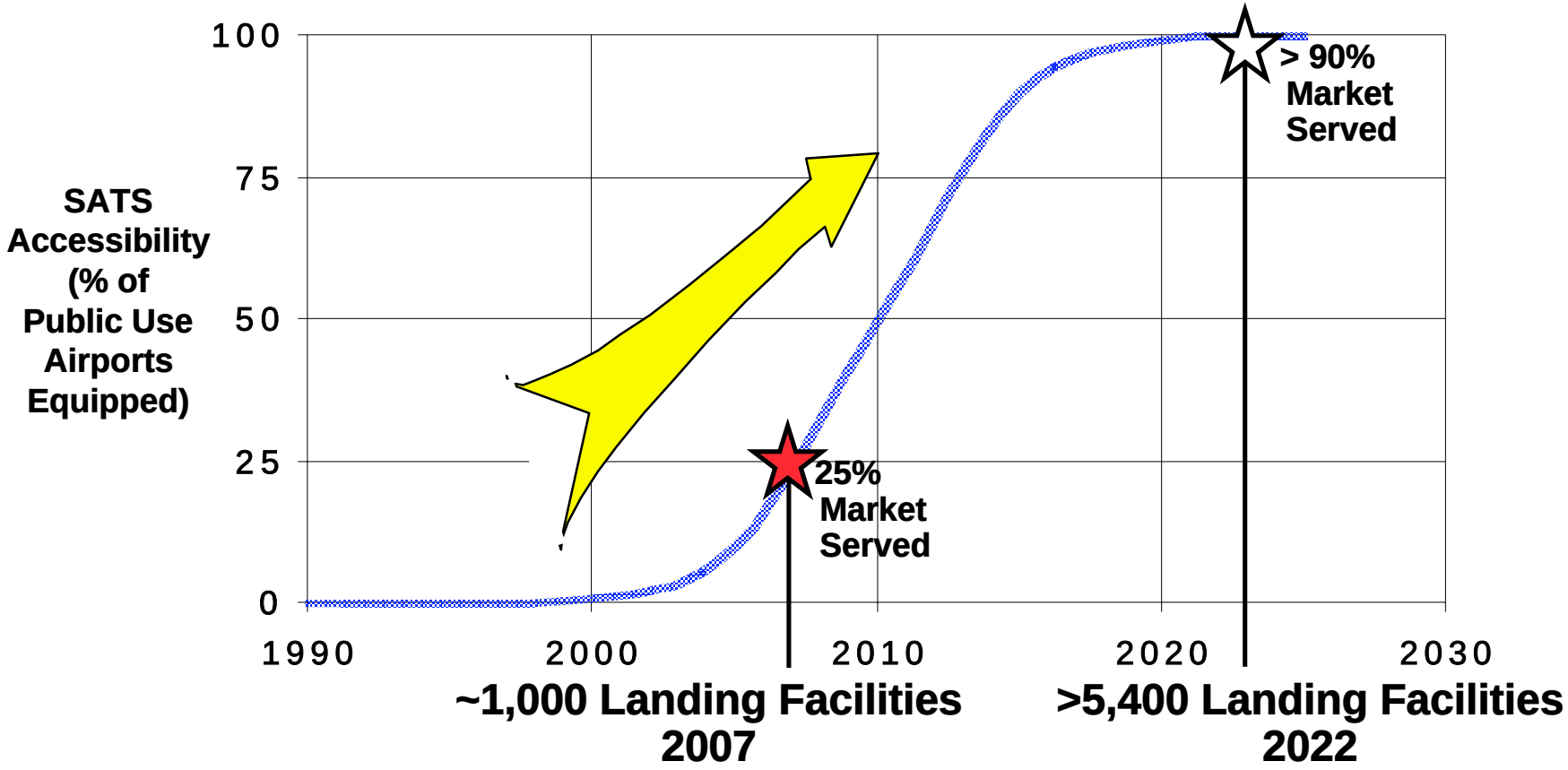
" Reduce public travel times by half in ten years and two-thirds in 25 years,"
(at equivalent highway system costs,
increasing mobility for all of the nation's communities
through advanced small aircraft transportation).



The Next Generation Cockpits and Aircraft

Lancair Columbia 300

Cirrus SR-20

Williams V-Jet

Toyota

The Pig in the Python

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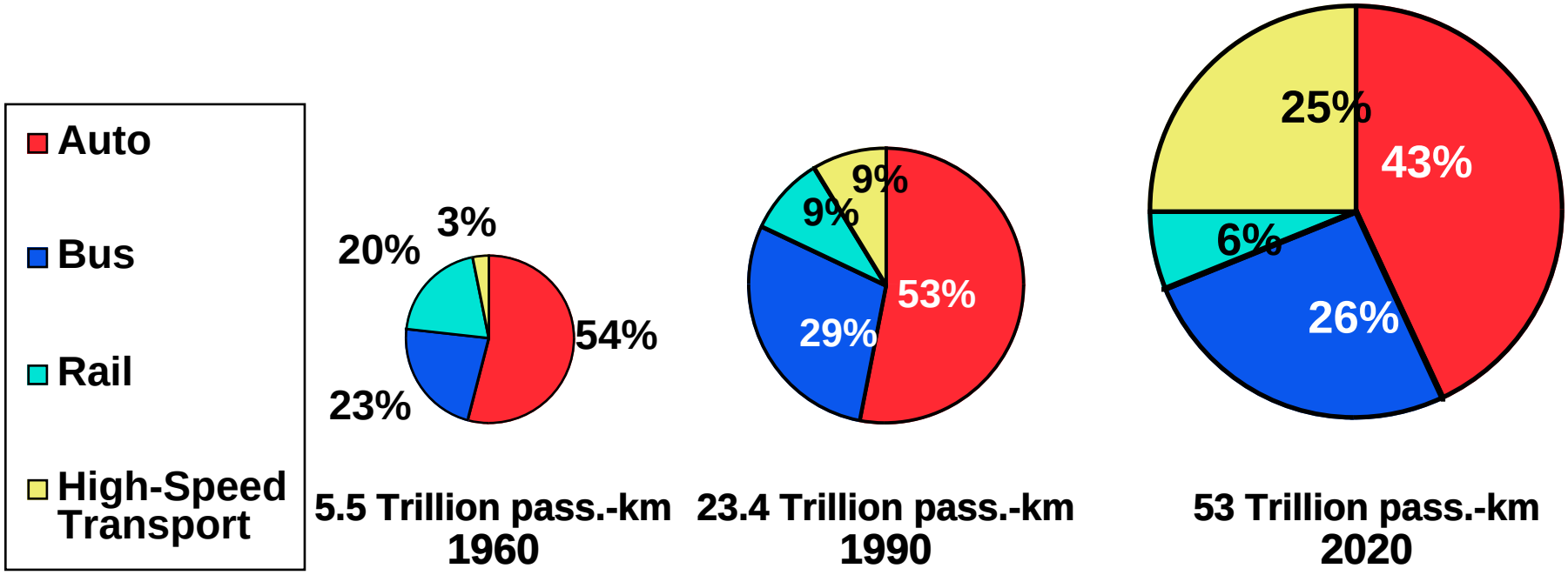
As *per capita* income rises,
per capita annual travel rises,
personal daily travel time budgets remain constant,
and
high-speed modes gain market share
(Schafer and Victor, Sci. Amer., Oct. 1997)



Global Travel Mode Shares will be driven by
the largest population and spending wave in history:
The Baby Boom

The Third Migration Wave

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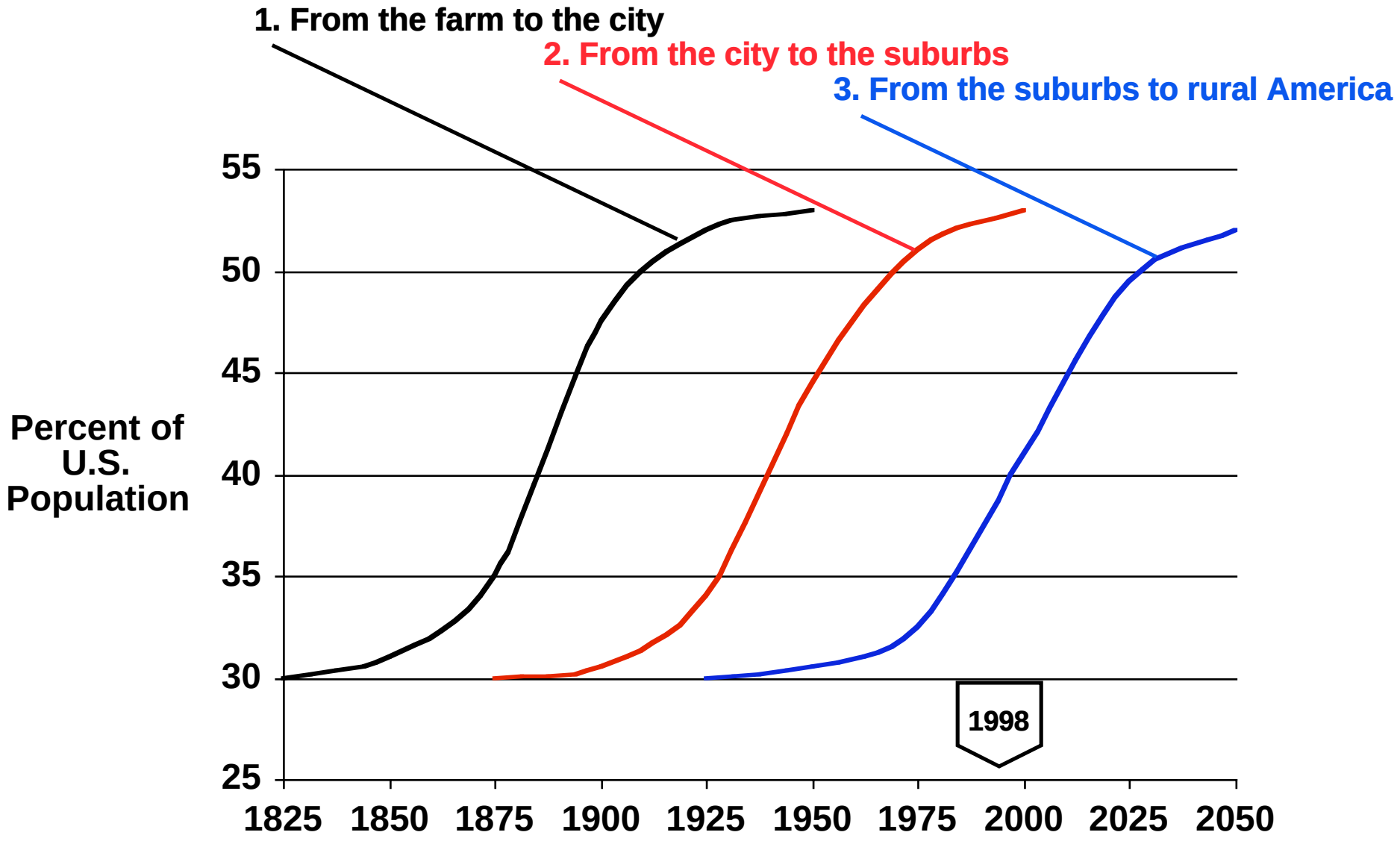
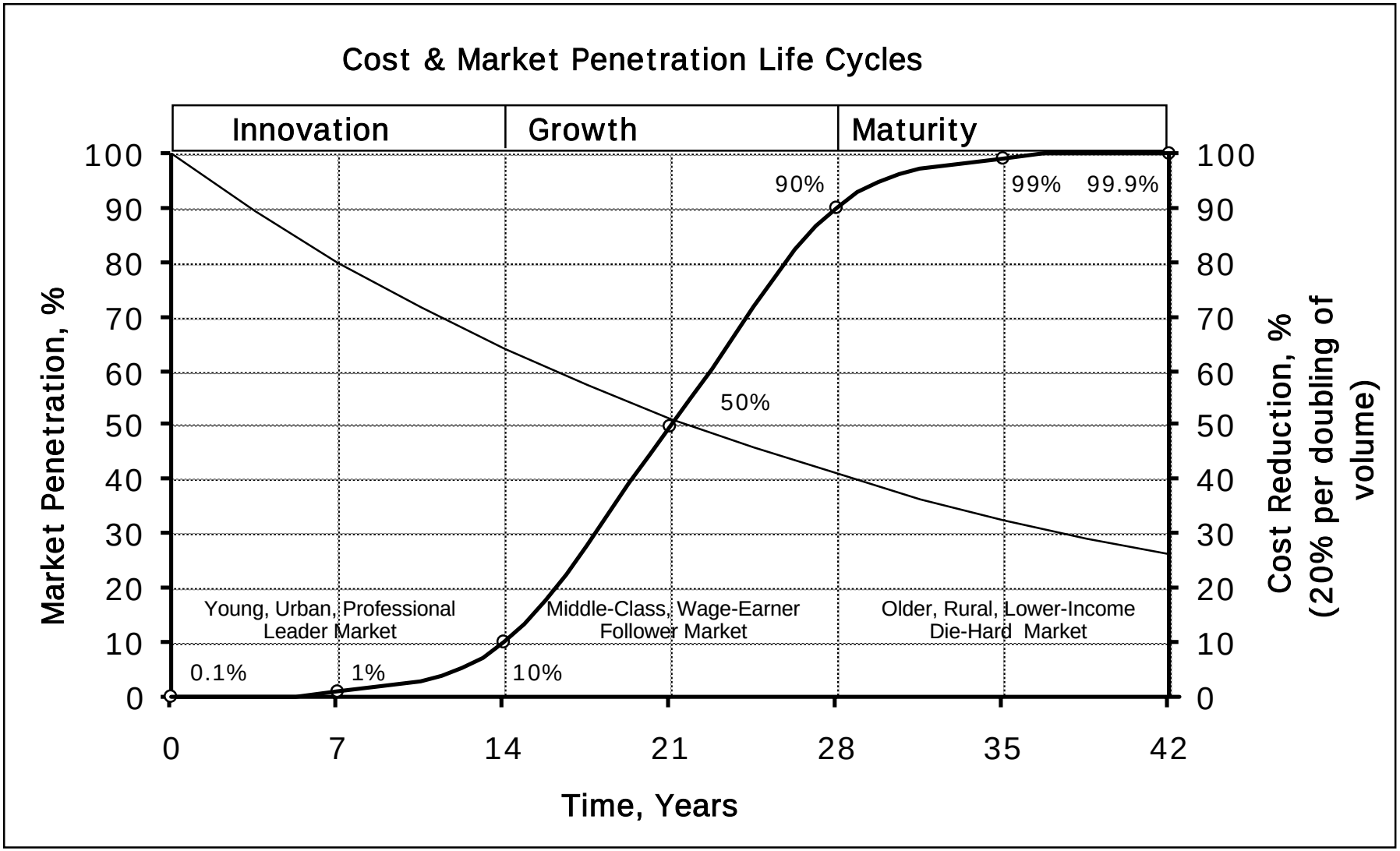
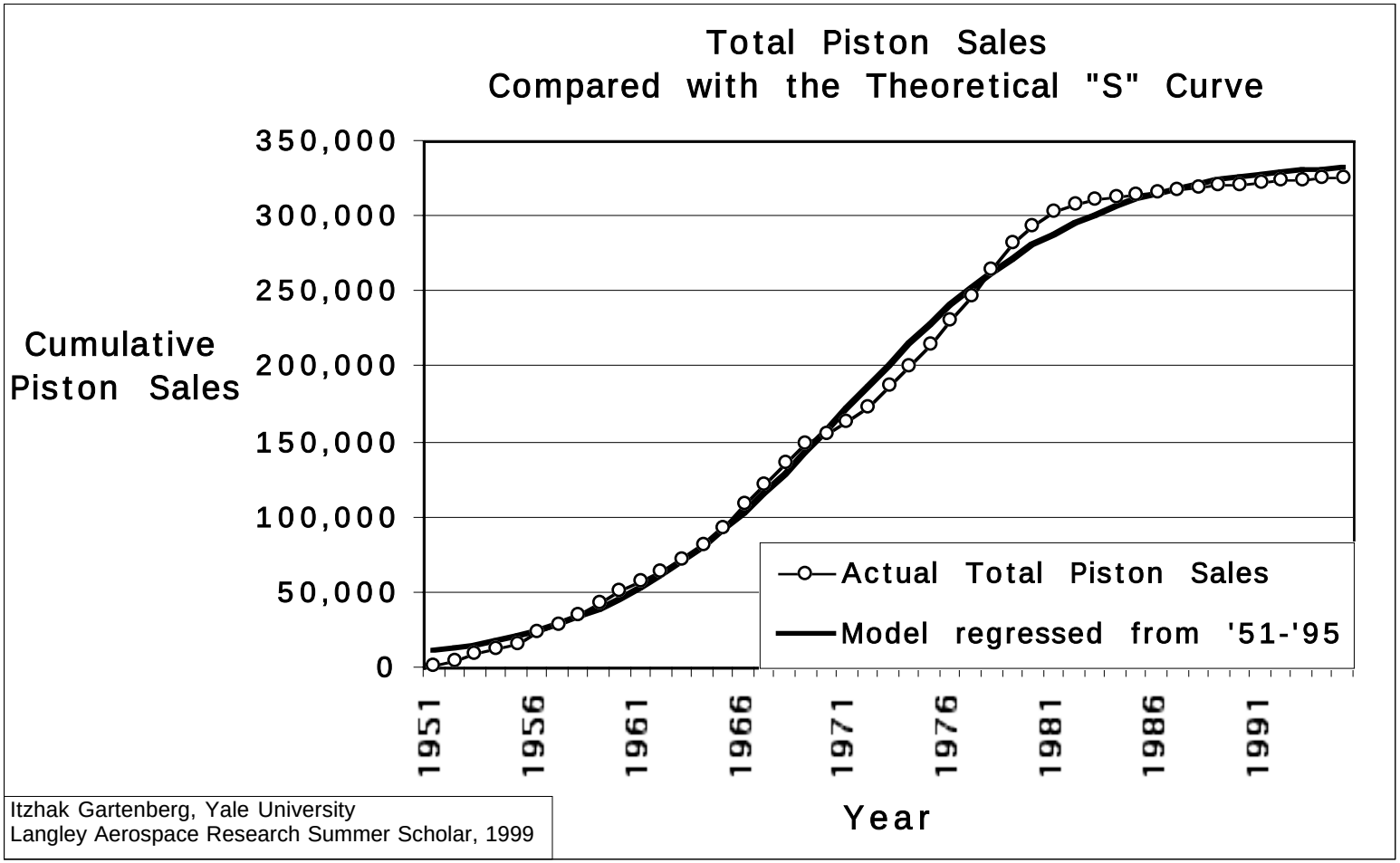


Innovation and Cost Life Cycles



Life Cycle of the Piston Aircraft Market



Life Cycles for Three Generations
Piston Aircraft

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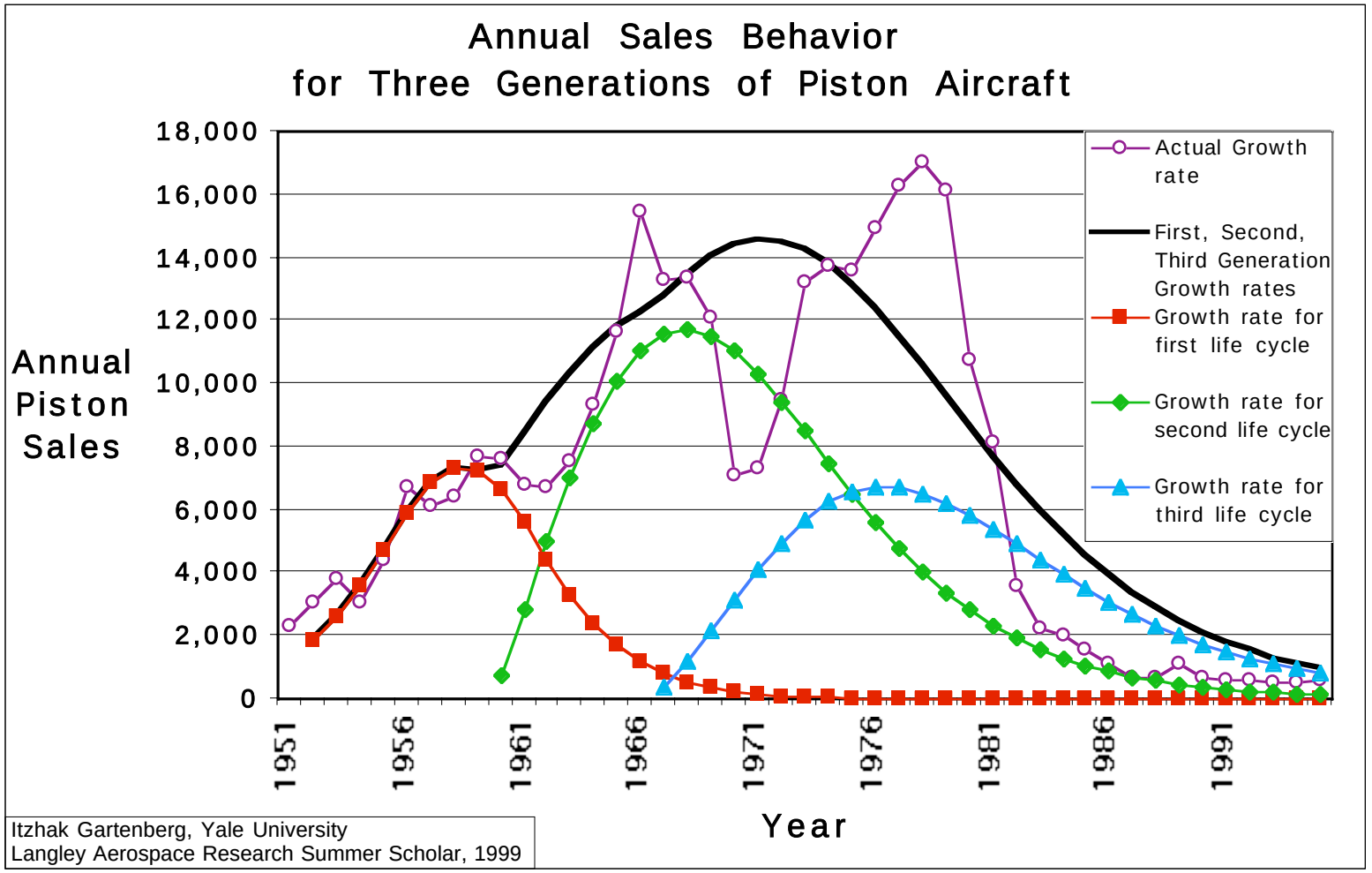

(R)evolutions in Higher Speed Travel

What is Next? More Speed to More Destinations

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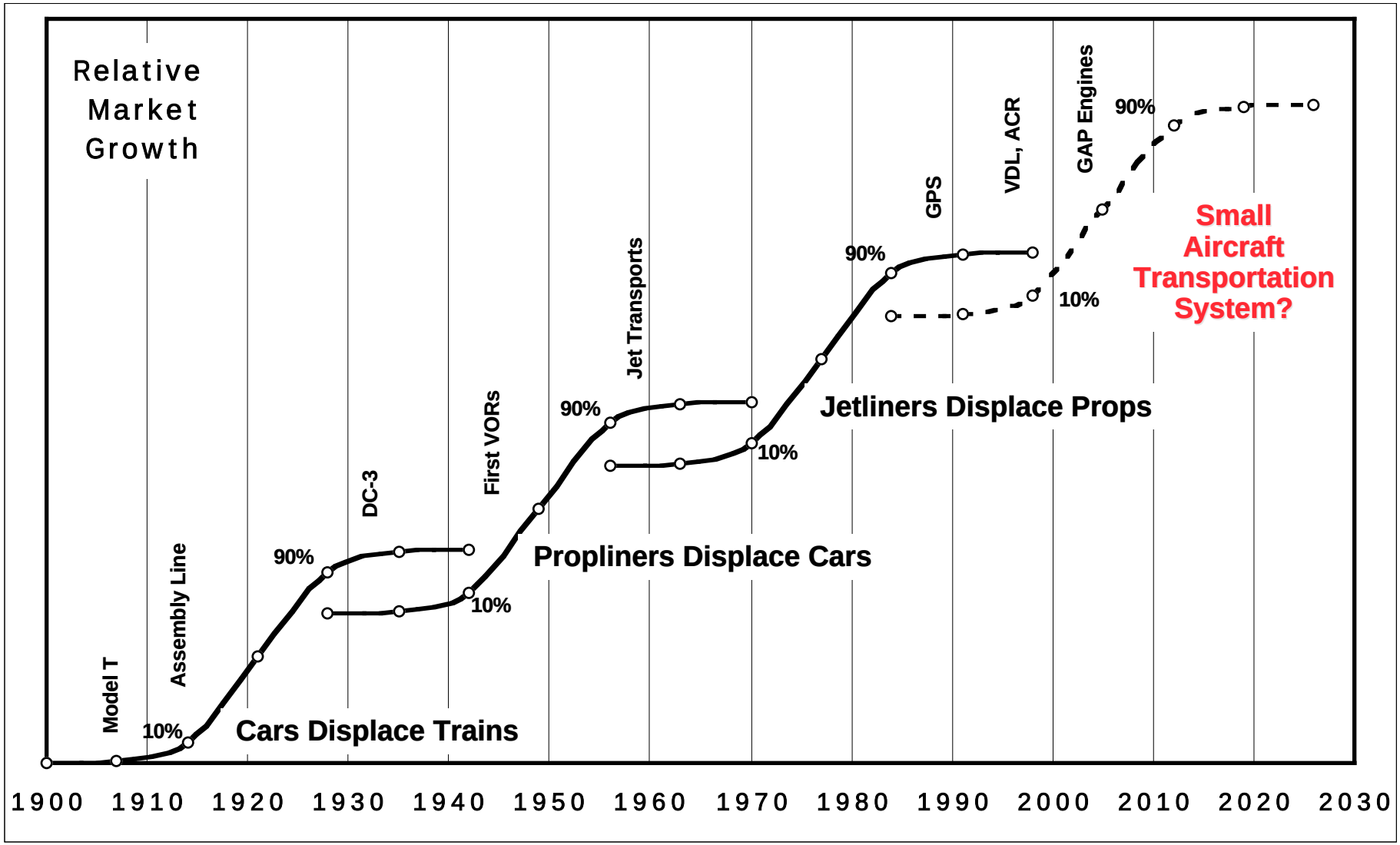
The "Atomic Structure" of Business Innovation Cycles



Small Aircraft Transportation System Mobility

"...doorstep-to-destination at four times the speed of highways..."

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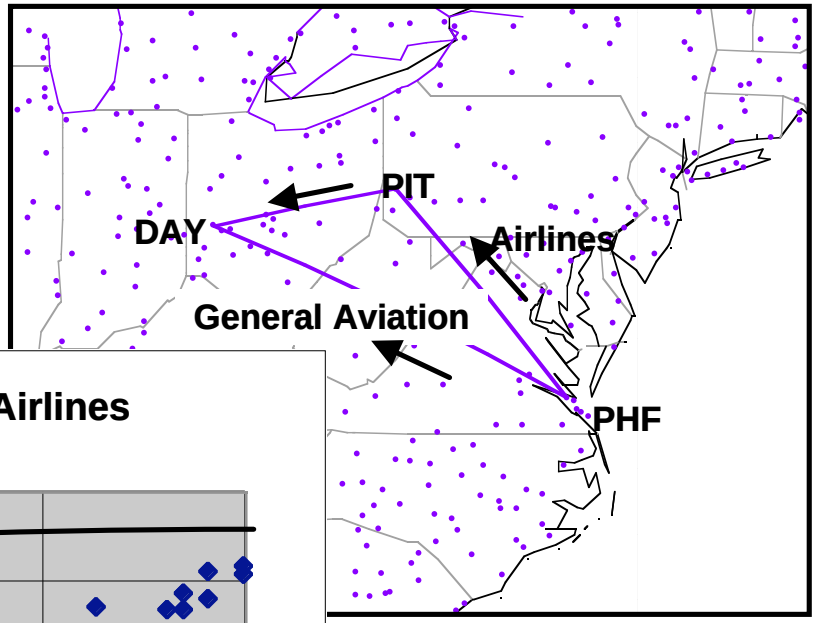
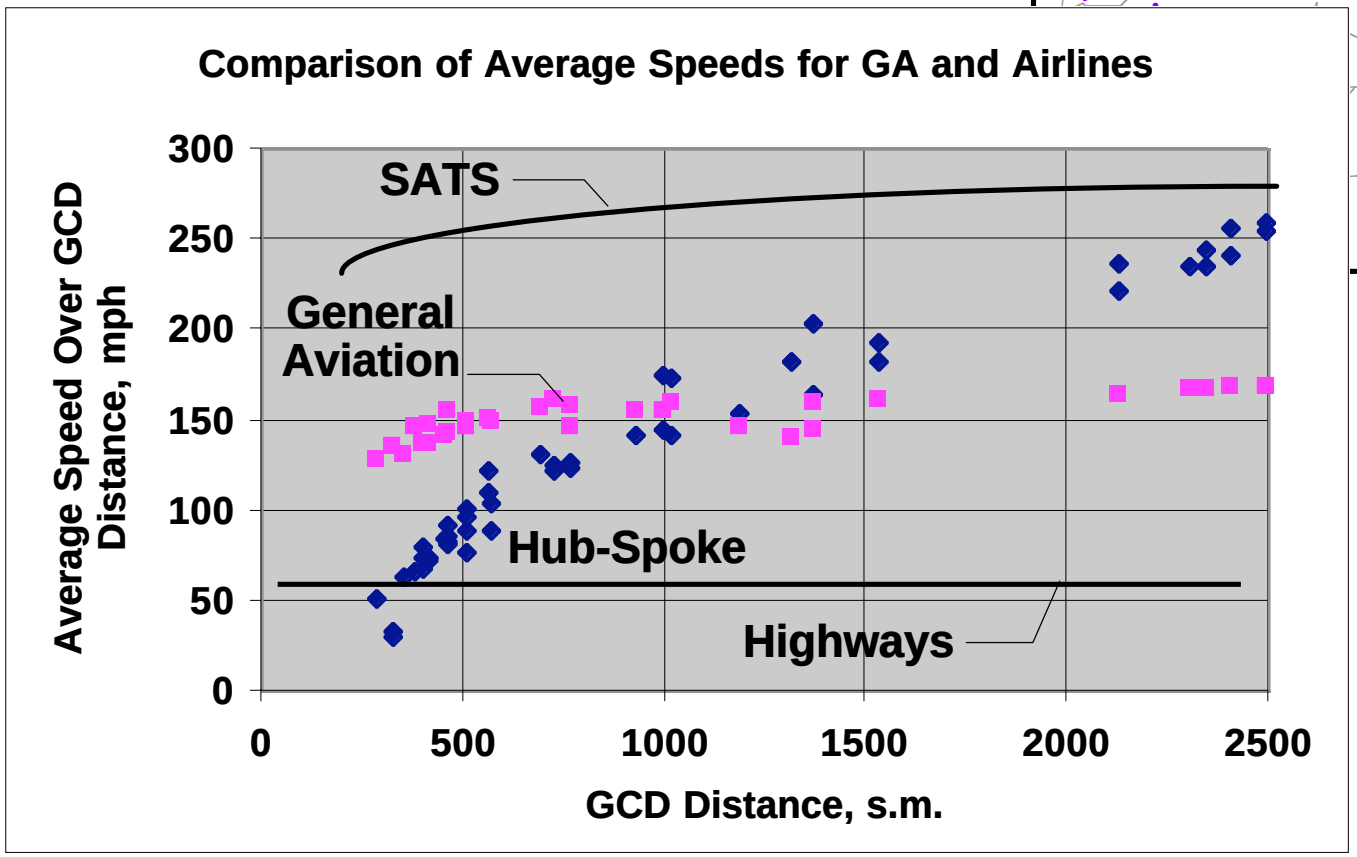
**SATS reduces travel times,
while highways and Hub-and-spoke travel times
will continue to increase.**





- Hub-Spoke: OAG times for 28 destinations
- General Aviation: time-optimized flight plans
- Including intermodal penalties (:45 +:45 for airline & :30+:30 for GA departure & arrivals)
- No GA destination benefit (for proximity of airports)
- SATS with new GAP engines: costs equal current General Aviation at 2 times the speed.

SATS Increases Accessibility and Mobility

(". . .creating access to more communities in less time. . .")

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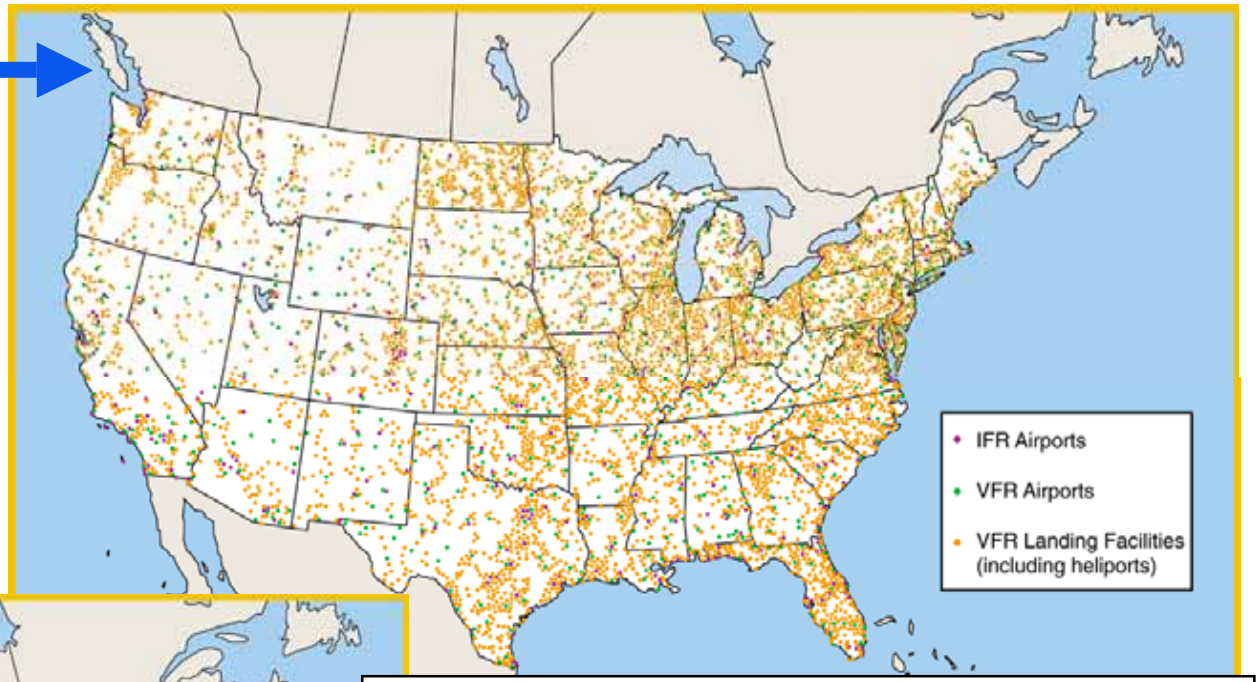
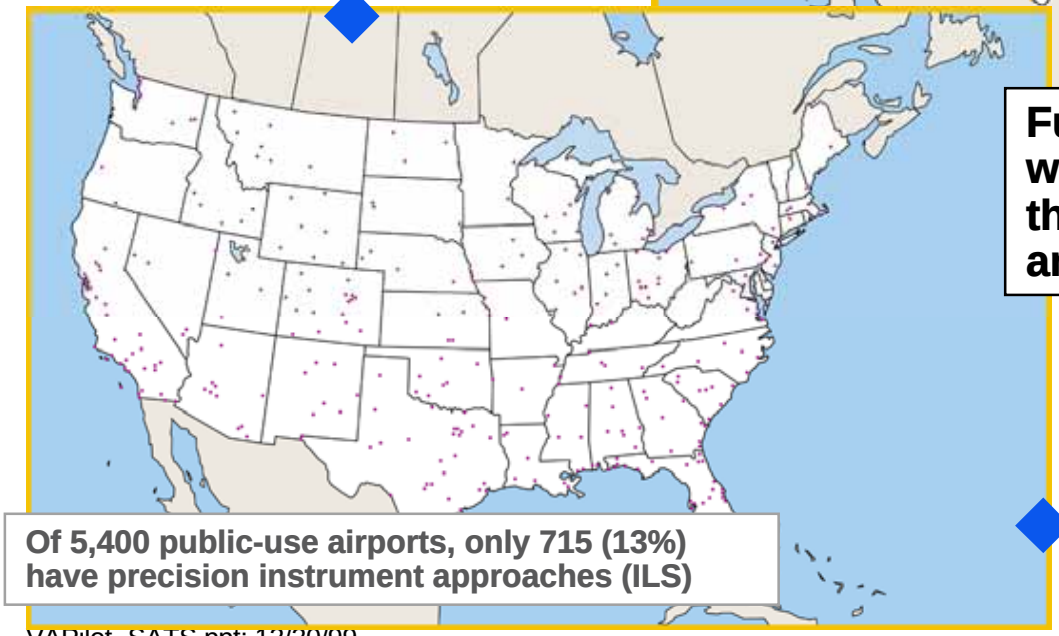
Expanded <u>Accessibility</u> to several times more destinations





Fully utilized 5,400 public-use near-all-weather landing facilities can increase theoretical NAS Throughput by more than an order of magnitude

Improved <u>Mobility</u> saving more travelers more time

Of 5,400 public-use airports, only 715 (13%) have precision instrument approaches (ILS)

Highway in the Sky Operations

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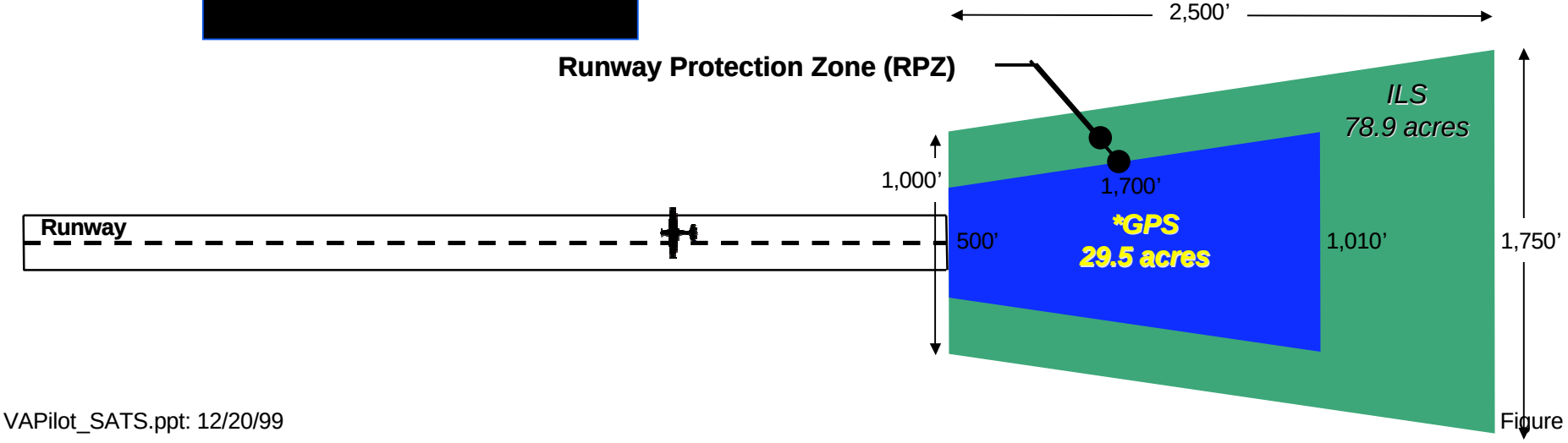
A Highway in the Sky satellite- & datalink-based approach guidance system may save over 49 acres per runway end compared to installing new ILS*

- **Saves land and system acquisition costs**
- **Minimizes dislocation of existing land holders**
- **Increases safety for operators and community**
- **Limits noise to inside of airport boundary**



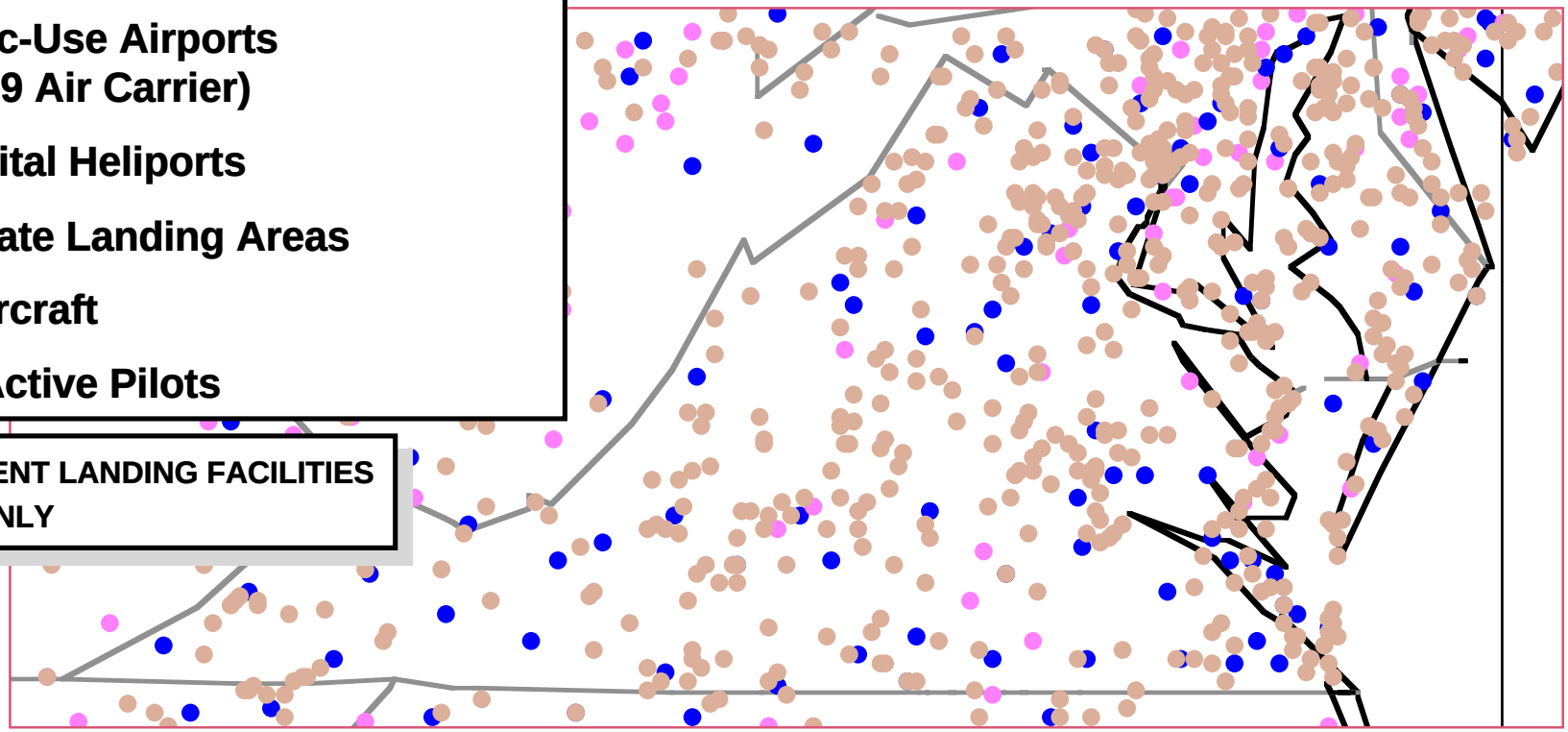
SATS Accessibility = Economic Development

Example for one state

Virginia General Aviation Today

- **~$175 Million in Economic Impact** (Primary & Secondary)
- **2,400 jobs from General Aviation** (Primary & Secondary)
- **68 Public-Use Airports (54 IFR; 9 Air Carrier)**
- **54 Hospital Heliports**
- **227 Private Landing Areas**
- **4,104 Aircraft**
- **15,525 Active Pilots**

SATS will enable ~90% more accessibility by air for all Virginia's communities, expanding economic opportunities for all regions

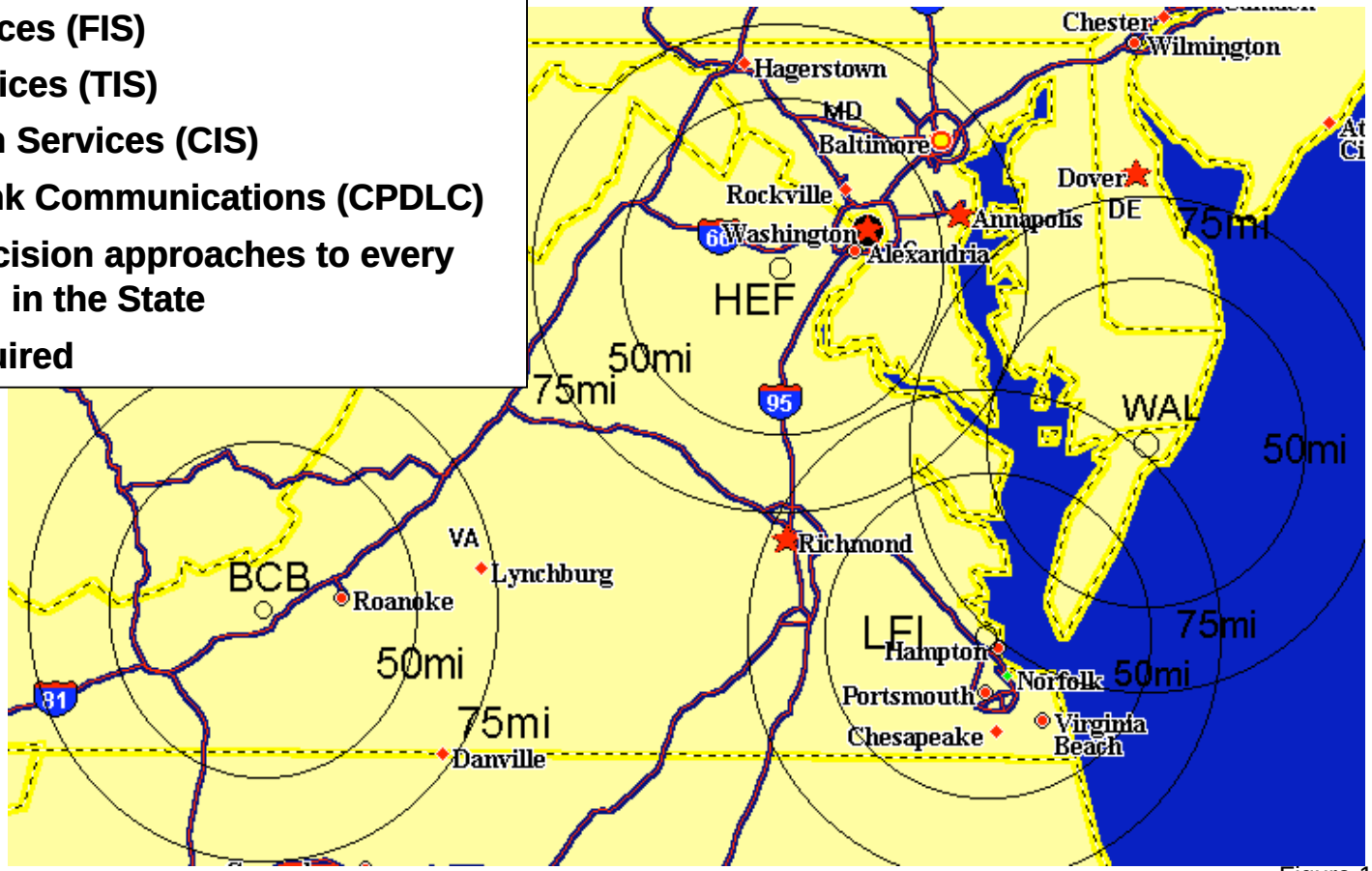


Virginia SATSLab

Datalink Infrastructure Facility (DIF)

Functions:

- **Client (Aircraft) -- Server (Landing Facility) Airborne Internet Architecture**
- **High speed digital Datalink**
- **Flight Information Services (FIS)**
- **Traffic Information Services (TIS)**
- **Commercial Information Services (CIS)**
- **Controller - Pilot Datalink Communications (CPDLC)**
- **Differential GPS for precision approaches to every runway end and helipad in the State**
- **No Tower, no radar required**



Current States Roles in SATS Planning

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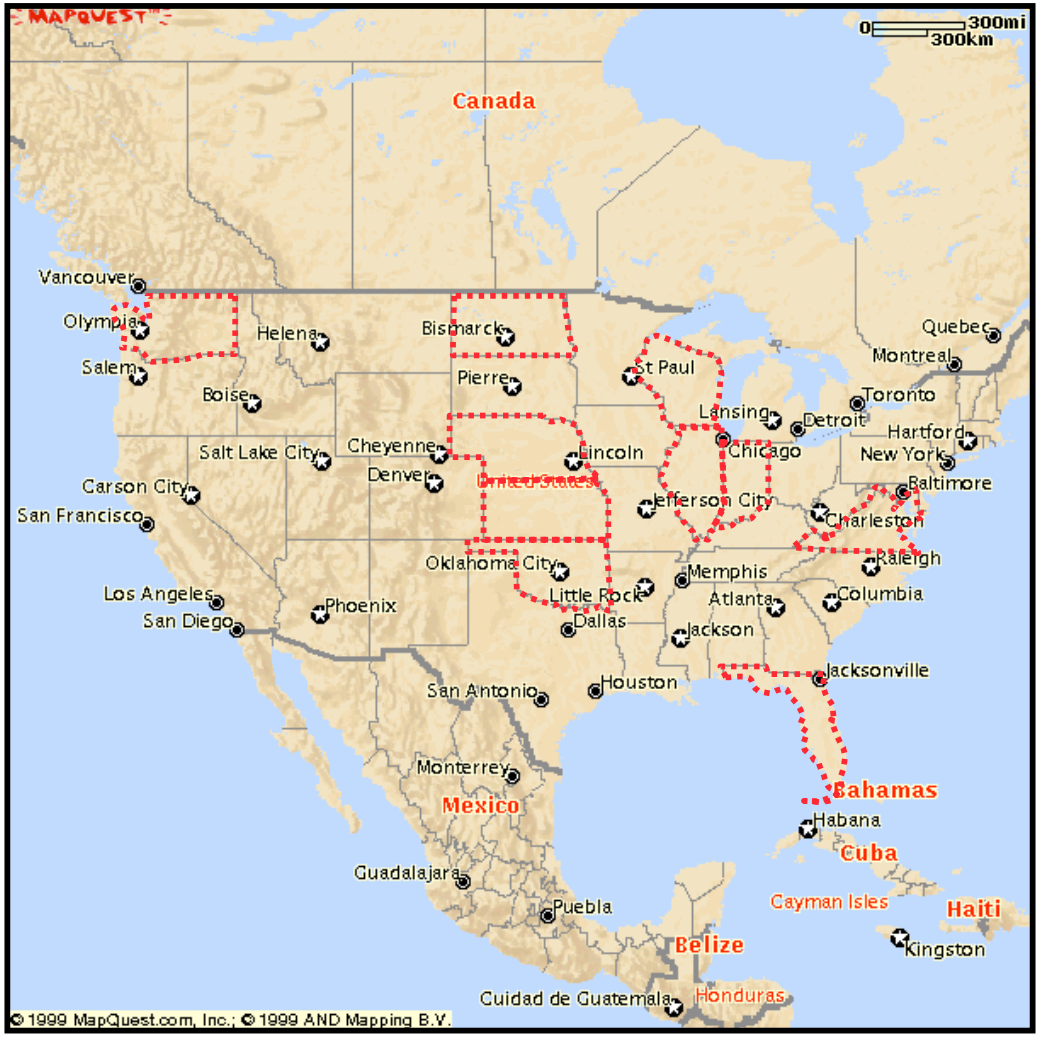
- **SATS "Leader" States Committed to Support Program Planning**
  1. **Virginia**
  2. **Florida**
  3. **Nebraska**
  4. **North Dakota**
  5. **Oklahoma**
  6. **Kansas**
  7. **Illinois**
  8. **Indiana**
  9. **Wisconsin**
  10. **Washington**
- **Aerospace States Association SATS Resolution, July, 1999**
- **Leveraged Research Funding:**
  - **EPSCoR funding leveraged (*e.g.,* Nebraska, Kansas)**
  - **NASA Space Grant Program potential leveraging**
  - **SBIR / STTR leveraging**



Technology Challenges -- 2007

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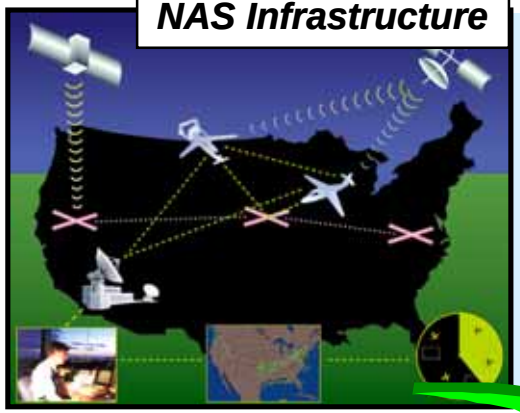
NAS Infrastructure



- "Smart" Airports (Mini-LAAS, Datalink FIS, TIS, Airport Databus/CIS Standards)
- ADS-B-based EnRoute & Terminal Free Flight at non-towered, non-radar airports
- "Virtual" TerPs
- Simultaneous Non-Interfering (SNI) Approaches
- Satellite-based Comm-Nav-Surveillance

Single-Crew Flight Deck Systems & Operations

- Decoupled controls
- Envelope protection
- Ride quality
- Affordable software certification
- Virtual Highways in the Sky/Electronic VFR
- Satcomm data radios

Pilot Training

- Onboard Cyber-Tutor
- InterNet Training
- 50% savings in time and cost

Close the Gap Between Transportation Demand and Supply

Airframe & Configuration

- <$30 per lb. composites, assembled
- Optimized ice, lightning, & crash protection
- Vertical Flight

Propulsion Systems

- <<$50,000 Turbine
- <$15,000 Compr.-Ignition
- Quieter propulsion
- Non-hydrocarbon options

Technology Investments

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- **Intermodal Transportation Systems Engineering**
  - ***Program System Engineering***
  - ***SATS Space Grant Partnerships***
  - ***National Public Outreach***
- **Digital Airspace Infrastructure**
  - ***Airborne Internet***
  - ***Smart Landing Facilities***
  - ***Runway Independent Aircraft Operations***
  - ***Showcase Demonstrations***
- **Robust Air Vehicles**
  - ***Autoflight***
  - ***Affordable Manufacturing***
  - ***Ultra-Propulsion***
  - ***Wireless Cockpit***
  - ***Cyber-Tutor***

Crosscutting Activities

- **"Transportation Systems Engineering" integrates and coordinates national requirements, technologies, consumer/community response, and program deliverables.**
- **"Showcase Demonstrations" serve as the basis for public policy decisions on deploying SATS infrastructure, based on consumer and community response. Demonstrations, implemented with State and Local Government partners, will integrate SATS capabilities and validate operating requirements for the full spectrum of terrain, meteorological, geographic, demographic, and airspace variables. Demonstrations are planned for FY03 and FY05.**
- **"SATS Space Grant" partnerships will be used to foster State and Local research and education using SATS aircraft and infrastructure. Hands-on experience with SATS technologies will allow state aviation and community authorities to make informed decisions on the investments for deployment of SATS infrastructure.**
- **"Public Outreach" will develop an understanding and acceptance of the SATS paradigm, *i.e.,* that it really is possible to reduce the time to travel point-to-point in a way that is as safe as airline travel and as easy and affordable as intercity automobile travel.**

Digital Airspace Infrastructure

- **Description of Technologies:**
- **A client-server-based architecture will provide information services on an "Airborne Internet" to support collaborative air traffic management. Aircraft and landing facilities will be interconnected nodes in a high-speed digital communications network providing instant identification and information services on demand with seamless linking to the global transportation system.**
- **"Smart Landing Facilities" will provide automation-enabled separation and sequencing in non-towered, non-radar, non-hub terminal airspace and simultaneous non-interfering operations for runway-independent aircraft at hubs. Landing facility information and status (runway lighting and condition) will be provided to airborne nodes (vehicles) by flight information services (FIS) including weather, traffic, flight plans, etc. while the commercial information services (CIS) will provide maintenance, fueling, intermodal connection, and other information.**
- **"Runway Independent Aircraft Operations" will enable hub & spoke airport throughput to be increased developing the infrastructure capability to use stub runways, taxiways, & vertiports instead of conventional runway under adverse weather conditions.**

Robust Air Vehicles

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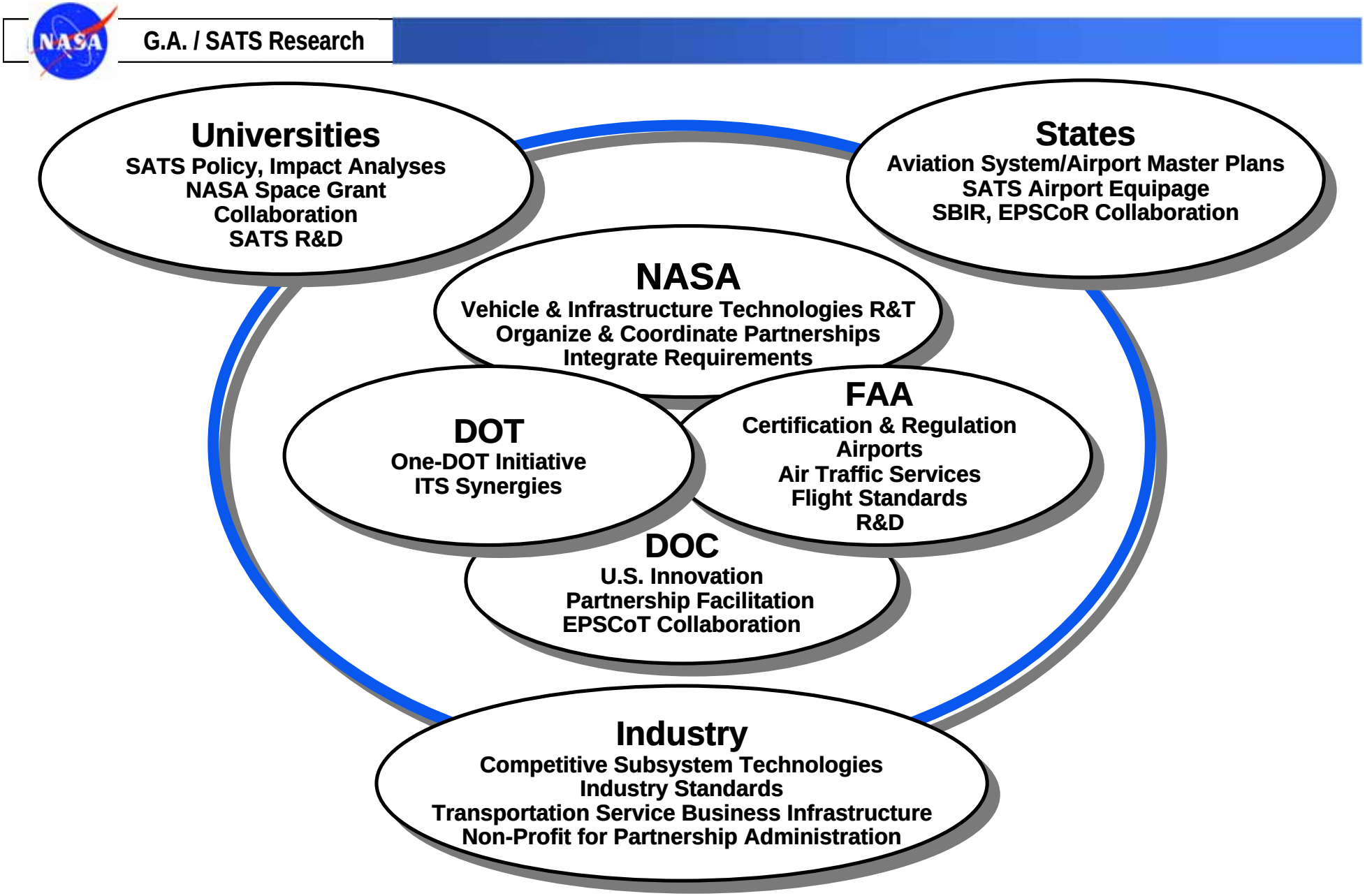
- **Description of Technologies:**
- **"Autoflight" technologies will reduce the complexity of aircraft control to car-like simplicity. Single-crew SATS aircraft operators will utilize simplified controls with automated assistance to navigate on virtual skyways using highway-in-the-sky operating procedures. The objective is to achieve commercial aircraft levels of safety and navigational performance while reducing cost and increasing mission reliability for both hired-pilot and self-flown operations.**
- **"Affordable Manufacturing" will integrate safety-enabling technologies (I.e. airbags, energy absorbing structures, lightning and ice protection) with high-volume, lean production technologies to achieve cost savings of 25% (minimum success requirement) to 50% (goal success requirement) over the AGATE/GAP Reference C aircraft baseline.**
- **"Ultra Propulsion" will enable environmentally friendly, maintenance-free, small engines assuring affordability, passenger comfort and community acceptance of aircraft operations. Automated, intelligent, fail-safe controls and health monitoring will increase levels of safety and reliability.**
- **Integrated avionics/controls architecture based on commercial off-the-shelf (COTS) systems for economies of scale, reliability, expandability, and certification will form the basis for the "Wireless Cockpit" and the communications interface with the "Airborne Internet".**
- **"Cyber-Tutor" will integrate advanced training technologies to reduce training time & cost to obtain and maintain all-weather safe flying skills. Training cost and calendar time will be reduced by 50% from present standards.**

Candidate Federal-States SATS Partnership Roles



SATS Program Description

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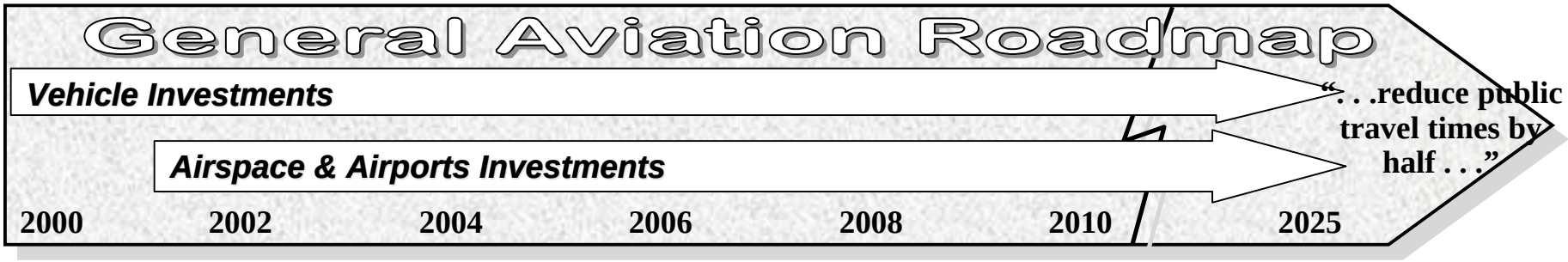

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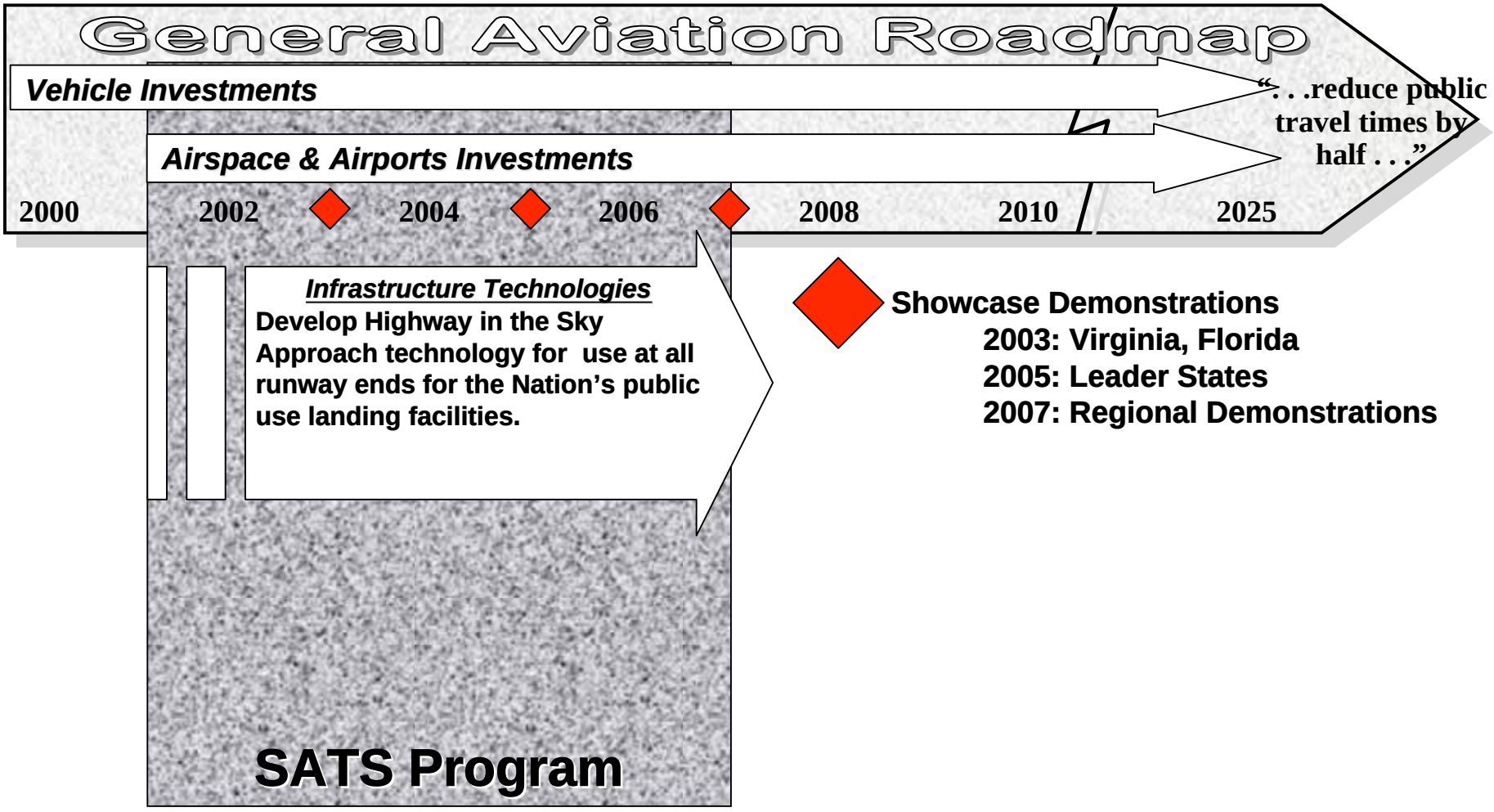

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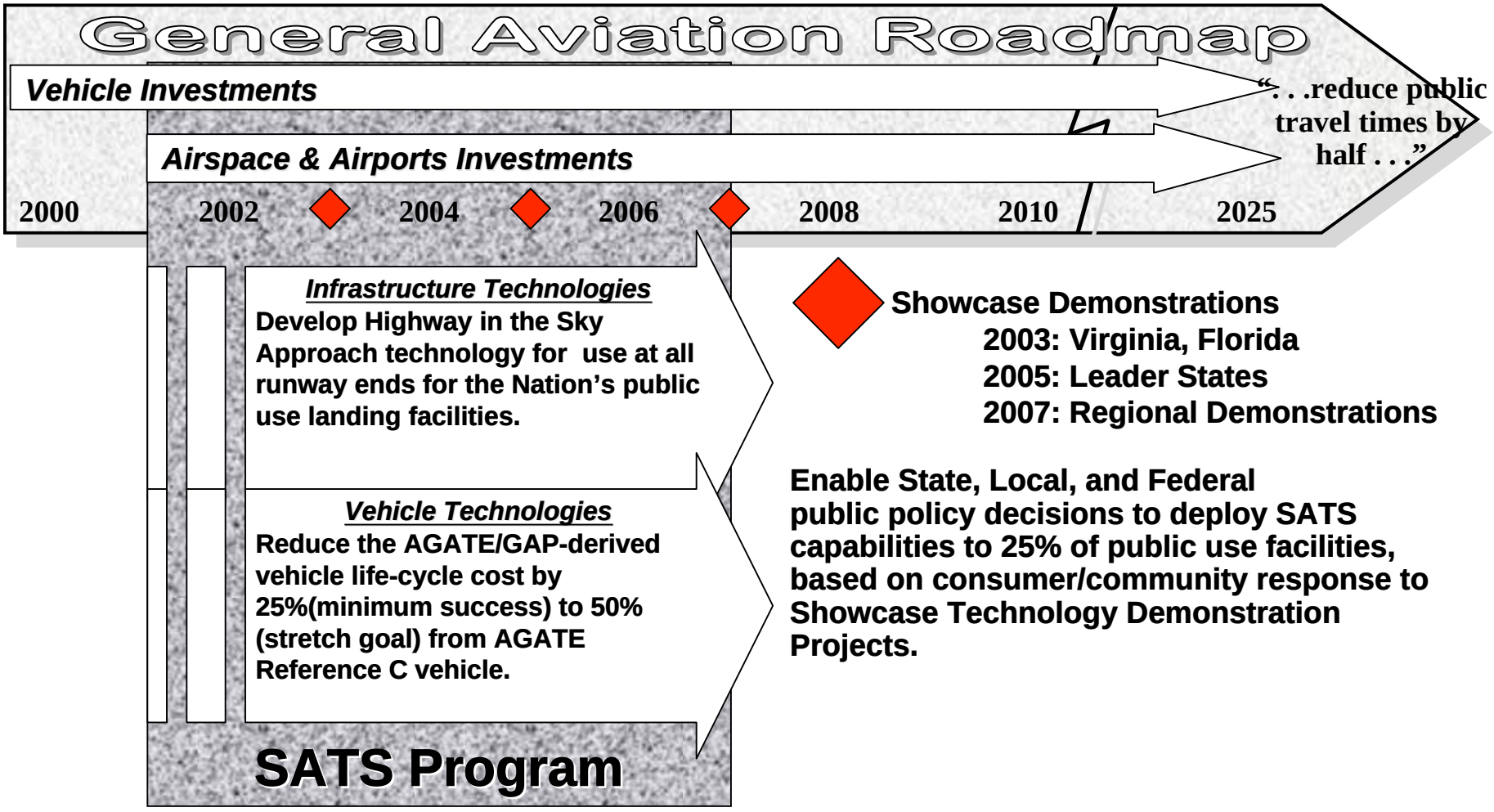

Action Planning

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SATS is:

- **"Smart" airports designed for transportation utility (= economic development)**
- **Highway In The Sky (HITS) guidance to virtually every runway end in America**
- **Single-crew systems and operating procedures with two-crew levels of safety and mission reliability**
- **LearJet-like performance for Mooney-like prices**

Action Planning

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Strategy:

- **Infrastructure will create pull for demand and products**
- **States are willing to invest in infrastructure**
- **Federal sector can be persuaded to invest**

Public Outreach Action Planning

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Strategy:

- Infrastructure will create pull for demand and products
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Suggested Actions:

- **Establish position for SATS technology strategy within regional transportation system plans**
- **Establish strategic action plan between Virginia SATSLab and community leaders**
- **Engage media in information planning for SATS initiative**

Conclusions

"The Smart Air Transport System is a safe travel alternative That frees people and products from transportation system delays Creating access to more communities in less time."

- **SATS is an investment that preserves America's options for mobility and accessibility in an era of saturation of the highway and hub-and-spoke systems.**
- **SATS investments build on a solid track record of accomplishment by American industry working in partnership with NASA and the FAA.**
- **SATS strategies position the U.S. leader communities for significant future growth potential in the emerging knowledge-based industrial expansion.**

Recommendations

"The Smart Air Transport System is a safe travel alternative That frees people and products from transportation system delays Creating access to more communities in less time."

- **Public outreach must be established to influence technology-based infrastructure development and deployment.**
- **States/communities need to see appropriate evidence of industry and government intentions regarding new transportation products and services.**
- **Communities must engage in public demonstration and education of new SATS transportation service concepts.**


The Smart Air Transport System is a safe travel alternative
freeing people and products from transportation delays,
by creating access to more communities in less time.
"Reduce public travel times by half in 10 years and two-thirds in 25 years"

Backup Charts

Program Products

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- **SATS technologies include:**
  - **"Smart Landing Facilities" provide automation-enabled separation and sequencing in non-towered, non-radar airspace**
  - **Client-server-based architecture for information services on an "Airborne Internet" to support collaborative air traffic management**
  - **Simplified automotive-like flight controls and displays for "Autoflight"**
  - **Quiet, clean, non-hydrocarbon-based "Ultra Propulsion" technologies for small engines**
  - **Automotive-like design and manufacturing of safe and affordable "Robust Personal Air Vehicles"**
  - **Integrated avionics standards and systems for tomorrow's "Wireless Cockpit"**
  - **Integrated advanced "Cyber-Tutor" technologies to reduce training time & cost for all-weather safe flying skills**
  - **"Intermodal Transportation Systems Engineering" integrates and coordinates national requirements, technologies, consumer/community response, and program deliverables.**
  - **"SATS Space Grant" partnerships for State and Local research and education using SATS aircraft and infrastructure**
  - **"Public Education" products for schools (K-12), university design competitions, and media information**
- **Showcase Demonstrations validate integrated technologies for safe, near all-weather accessibility for potential deployment to virtually all landing facilities in the nation with affordable, user-friendly vehicles.**
- **SATS provides public policy makers with consumer and community responses to SATS transportation capabilities and environmental considerations in support of policy, regulatory, and funding decisions.**
- **SATS assesses integrated system safety.**
- **SATS technologies are validated to TRL Level 6 and 7.**

SATS Planning Assumptions

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- **Alliance-based program**
- **Cost-sharing (50/50 model)**
- **Collaboration for pre-competitive technologies**
- **Competition for competitive technologies**
- **FY 2001 to FY 2008 program with major demonstrations on 2-year centers**
- **FAA SATS Mission Need Statement influences NAS Architecture (5.x)**
- **U.S. industry and States will meet the challenge**

SATS Concept & Benefits

- ***SATS Includes:***
  - **"Smart Landing Facilities" provide automation-enabled separation and sequencing in non-towered, non-radar airspace**
  - **Client-server-based architecture for information services on an "Airborne Internet" to support collaborative air traffic management**
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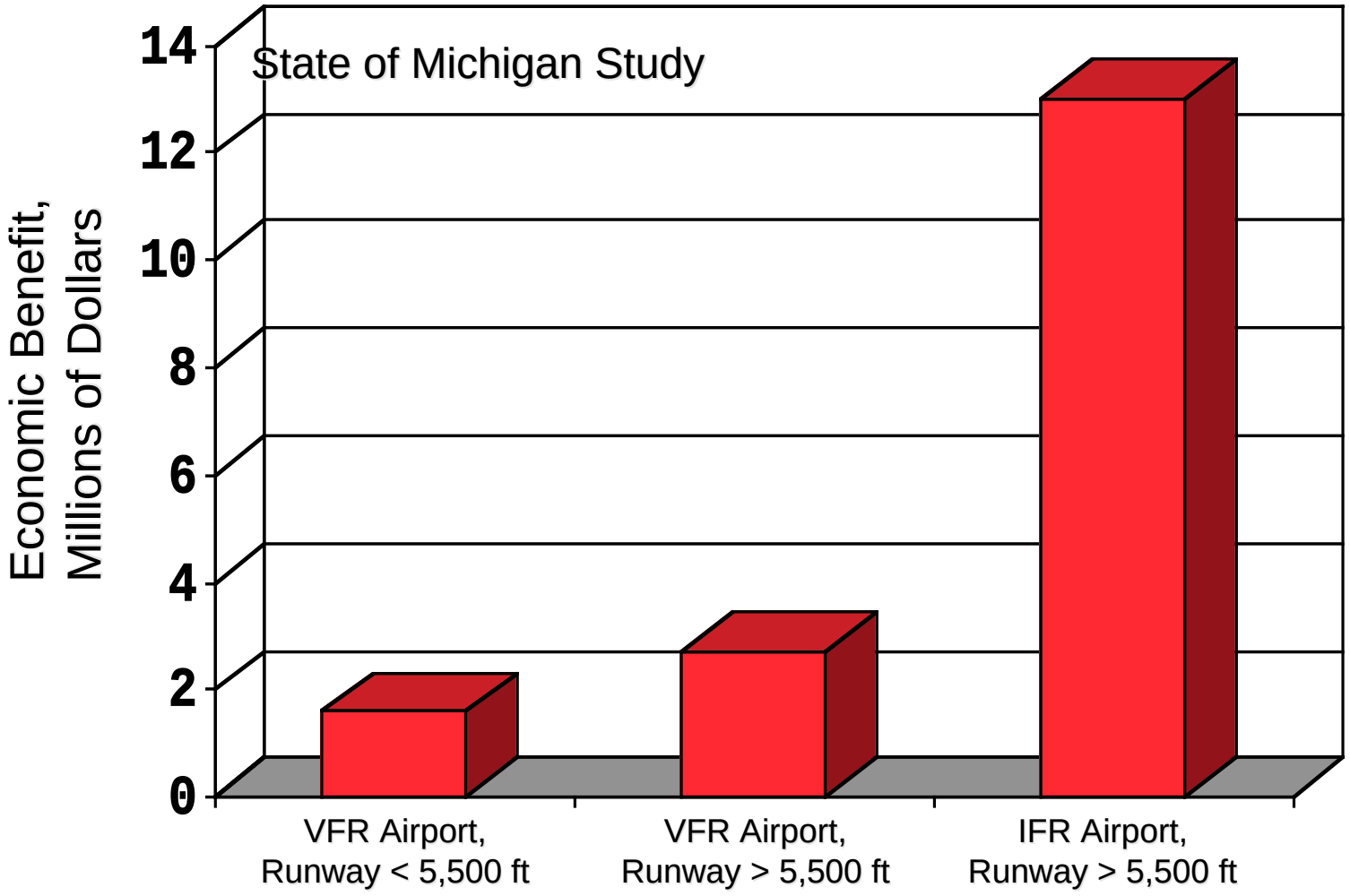
  - **"Showcase Demonstrations" implemented with State and Local Government partners to integrate SATS products as basis for public policy decisions on SATS infrastructure**

All-Weather Accessibility Means Economic Development



VFR - Visual Flight Rules
IFR - Instrument Flight Rules

Resolution of the Aerospace States Association

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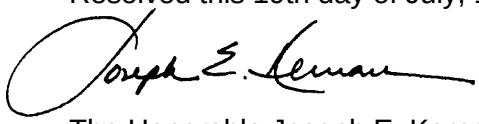
- **RESOLUTION REGARDING THE PROPOSED**
- **SAFE SMALL AIRCRAFT TRANSPORTATION SYSTEM (SATS)**

- **WHEREAS** a variety of forces are converging to reduce the effectiveness of the nation's existing highway and hub-spoke air transport system to meet the growing needs of short distance, inter and intra-state travel; and
- **WHEREAS** these forces include the maturing of the hub-spoke air transport system, the increasing gridlock on the nation's highways, and the increasing value of human time; and
- **WHEREAS** the nation has an existing infrastructure of 17,000 airports for small, General Aviation Aircraft, of which at least 5,000 could be modified to meet the nation's emerging short distance transportation needs; and
- **WHEREAS** the Federal Government, acting through NASA, has undertaken cooperative technology development efforts with the nation's General Aviation industry to develop a new era of aircraft capable of effectively using these 5,000 airports; and
- **WHEREAS** the investment in, and control of ground infrastructure associated with such airports is under the jurisdiction of the nation's State and local authorities; and
- **WHEREAS** the Federal Government has offered to develop, with State governments, the means to upgrade those 5,000 airports with new capabilities, such as Global Positioning Systems (GPS), and link them together into a system to be known as the Small Aircraft Transportation System (SATS); and
- **WHEREAS** the development of a SATS has the potential to generate transportation-driven economic development benefits; and
- **WHEREAS** the coordinated development of a SATS would be of substantial benefit to the State governments in meeting the transportation needs of their citizens; and
- **WHEREAS** it is the purpose of the Aerospace States Associations to identify, support, and assist in the implementation of aerospace policies which involve coordination between the Federal and State governments,
- **NOW THEREFORE, BE IT RESOLVED** that the Aerospace States Association endorses and supports efforts by the Federal Government to undertake the planning and implementation associated with the creation of a Small Aircraft Transportation System (SATS).
- Resolved this 19th day of July, 1999 by a unanimous vote of the members voting.



- The Honorable Joseph E. Kernan (Lt. Governor, Indiana)
- Chair

A New Beginning

(Resulting from Current NASA Aeronautics Investments)

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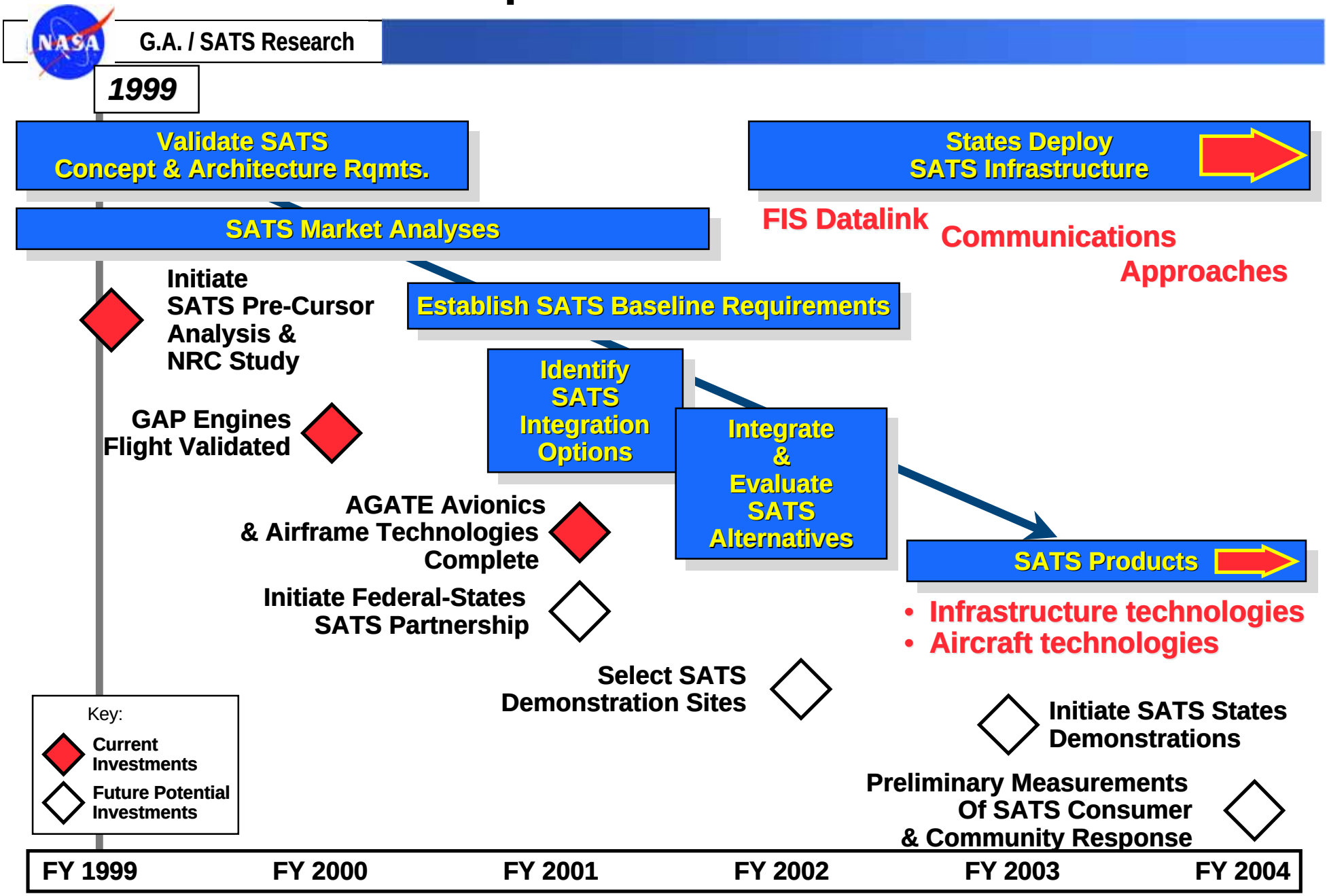
- **AGATE Alliance: 70 industry competitors collaborated under NASA leadership to create new, far-reaching technologies cockpit, airframe manufacturing, and flight training (1994 - 2001)**
- **Two newcomers represent the first new Single-Engine, Type-Certificated Airplanes in 15 years. Technologies derived from past 20 years of NASA Aeronautics research.**
- **Corporate commitments to new products and services signal the long-term potential for payoffs from these technology strategies**
- **Highway in the Sky (HITS) capabilities offer potential to deploy GPS/graphically guided approaches to all virtually all landing sites in the nation, leading to a 21st century Small Aircraft Transportation System**

GA Roadmap Milestones FY 2000 - 2004



NASA & FAA Collaboration in GA R&D Investments

G.A. / SATS Research

Lead		
NASA	AGATE	New Aircraft
NASA	GAP	New Engines
FAA	HeliSTAR (1996 Atlanta Olympics)	Free Flight
NASA	Aviation Safety Program	Safety Intervention Technologies
FAA	Capstone (Alaska)	Airspace, Procedures & CNS
FAA	Cargo Airlines Ohio River Valley	ADS-B
FAA	Safer Skies	Safety Intervention Procedures
FAA	2002 Olympics (Salt Lake)	Airspace, Procedures & CNS
FAA	Low Altitude Infrastructure (Gulf of Mexico)	EnRoute & Terminal Procedures for low altitude infrastructure
NASA	SATS	Aircraft & Infrastructure

FAA/NASA Executive Committee

SATS Agreement

SATS Program Description:

"The Small Aircraft Transportation System concept is a safe travel alternative that frees people and products from transportation system delays, creating access to more communities in less time."

Joint NASA-FAA supporting statements are:

- FAA and NASA are working together to define a SATS operational concept as it relates to the transportation infrastructure of the U.S. and will begin a NASA funded research initiative to explore the feasibility and viability of implementing that concept.
- Under the charter of the NASA/FAA Executive Committee, the agencies agree to form a working group to define the FAA-NASA engagement in SATS program development and implementation planning.